Docket #: S18-012

Spins - Inverse design software for nanophotonic structures

Summary of invention:

This software suite called **Spins**, automates the design of arbitrary nanophotonic devices by leveraging gradient-based optimization techniques that can explore a large space of possible designs. The resulting devices have higher efficiencies, smaller footprints, and novel functionalities.
Spins is now being licensed to any interested parties through Stanford's Office of Technology Licensing (OTL).
Spins-B is an open source version available on Github (OTL).

Problem: Currently, the design of photonic devices and systems remains extremely labor-intensive and requires engineers with detailed knowledge and extensive experience.

Solution: To improve upon traditional photonics design methods, the Vuckovic group at Stanford University has developed **Spins**, an automated photonics design suite that can:

- Automatically design photonic devices with no human guidance ?
- Design any passive, linear photonic element ?
- Efficiently search the full space of fabricable devices using gradient-based optimization ?
- Produce designs that are significantly more compact, have higher performance, and potentially realize novel functionalities ?
- Incorporate fabrication constraints to ensure devices are readily fabricable ?
- Streamline the design process for planar waveguide devices and grating couplers through the use of provided device design kits which only require the user to input high level parameters

Stage of Development:

- **Prototypes**-The team designed and experimentally demonstrated a spatial-mode demultiplexer, wavelength demultiplexer, compact broadband power splitter and directional coupler.
- A module of **Spins** for grating couplers is described in Stanford docket **S18-019 Fully-automated design of grating couplers**.

Licenses

- Commercial site and distribution licenses are available.
- Academic and US government lab licenses are available at a discounted price. Contact the Stanford Office of Technology Licensing Office for more details.

Applications

- **Designing innovative structures for efficient optical devices**
- Examples include silicon photonics components, such as power splitters, wavelength demultiplexers, fiber-to-chip grating coupler design, mode converters, metasurface design, quantum circuits (photonic and microwave) LEDs, solar cells, lasers designs

Advantages

- **Fully automated and efficient**
- Allows user to 'design by specification'
- Uses gradient-based optimization methods not derivative-free optimization methods which are computationally inefficient and only work well for small numbers of degrees of freedom
- **Devices can be easily fabricated by standard lithography techniques**

Publications

- **On-chip integrated laser-driven particle accelerator,** Neil V. Sapra, Ki Youl Yang, Dries Vercruysse, Kenneth J. Leedle, Dylan S. Black, R. Joel England,Logan Su, Rahul Trivedi, Yu Miao, Olav Solgaard, Robert L. Byer, Jelena Vu?kovi? *Science* (2020)

- **Inverse-designed non-reciprocal pulse router for chip-based LiDAR,** Ki Youl Yang, Jinhie Skarda, Michele Cotrufo, Avik Dutt, Geun Ho Ahn, Mahmoud Sawaby, Dries Vercruysse, Amin Arbabian, Shanhui Fan, Andrea Alù, Jelena Vu?kovi? *Nature Photonics* (2020)
- **Inverse-Designed Photonics for Semiconductor Foundries,** A.Y. Piggott, E.Y. Ma, …J. Vuckovic *ACS Photonics* Feb. 14, 2020.
- **Nanophotonic inverse design with SPINS: Software architecture and practical considerations,** Logan Su, Dries Vercruysse, Jinhie Skarda, Neil V. Sapra, Jan A. Petykiewicz, and Jelena Vu?kovi?. *Applied Physics Reviews* 7, 011407 (2020) Featured in ScienceDaily, PhysOrg, EurekAlert, and more.
- **Inverse design and demonstration of broadband grating couplers**, Neil V. Sapra, Dries Vercruysse, Logan Su, Ki Youl Yang, Jinhie Skarda, Alexander Y. Piggott, Jelena Vu?kovi?. *IEEE Journal of Selected Topics in Quantum Electronics* (2019)
- **Fully-automated optimization of grating couplers,** Logan Su, Rahul Trivedi, Neil V. Sapra, Alexander Y. Piggott, Dries Vercruysse, Jelena Vu?kovi?. *Optics Express* (2018)
- **Inverse design and demonstration of a compact on-chip narrowband three-channel wavelength demultiplexer,** Logan Su, Alexander Y. Piggott, Neil V. Sapra, Jan Petykiewicz, Jelena Vu?kovi?. *ACS Photonics* (2018)
- **Fabrication-constrained nanophotonic inverse design,** Alexander Y. Piggott, Jan Petykiewicz, Logan Su & Jelena Vu?kovi?. *Scientific Reports* 7, 1786 (2017)
- **Inverse design and demonstration of a compact and broadband on-chip wavelength demultiplexer,** Alexander Y. Piggott, Jesse Lu, Konstantinos G. Lagoudakis, Jan Petykiewicz, Thomas M. Babinec, and Jelena Vu?kovi?, *Nature Photonics* 9, 374–377 (2015)
- **Inverse design and implementation of a wavelength demultiplexing grating coupler,** Alexander Y. Piggott, Jesse Lu, Thomas M. Babinec, Konstantinos G. Lagoudakis, Jan Petykiewicz, Jelena Vuckovic, *Scientific Reports* 4, 7210, (2014) [Supplementary info]
- **Nanophotonic computational design** Jesse Lu and Jelena Vuckovic, *Optics Express* Vol. 21, 11, pp. 13351-13367 (2013)
- **Spins Overview**
- **Spins Tutorial**
- **Spins Usage Example**

Innovators

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